

## CLAIMS

What is claimed is:

1. A method comprising forming a volume hologram in at least a portion of an optical medium, the volume hologram comprising at least one of temporal, spectral, and spatial transformation information, the volume hologram comprising a plurality of diffractive elements exhibiting a positional variation in at least one of amplitude, optical separation, and spatial phase over some portion of the volume of the hologram, the transformation information for transforming a chosen input signal into a chosen output signal as the input and output signals propagate within the optical medium.
2. The method of Claim 1, wherein the volume hologram is imparted using at least one technique chosen from the group consisting of photolithography, electron beam lithography, stamping, nanoimprinting, laser writing, etching, mechanical abrasion, ultrasonic material removal, heat deformation, laser ablation, and photosensitive exposure, and combinations thereof.
3. The method of Claim 1, propagation of the input and output optical signals within the optical medium substantially unguided in three dimensions.
4. The method of Claim 3, the volume hologram comprising temporal transformation information.
5. The method of Claim 3, the volume hologram comprising spectral transformation information.
6. The method of Claim 3, the volume hologram comprising spatial transformation information.
7. The method of Claim 1, wherein the optical medium comprises a planar optical waveguide, propagation of the input and output optical signals within the planar waveguide substantially guided in at least one dimension by the planar waveguide.
8. The method of Claim 7, comprising imparting a pattern onto at least a portion of at least one surface of the planar optical waveguide, thereby forming the volume hologram therein.

- 1 9. The method of Claim 7, comprising imparting a pattern within at least a portion of  
2 the volume of the planar optical waveguide, thereby forming the volume hologram  
3 therein.
- 4 10. The method of Claim 7, the volume hologram comprising temporal transformation  
5 information.
- 6 11. The method of Claim 7, the volume hologram comprising spectral transformation  
7 information.
- 8 12. The method of Claim 7, the volume hologram comprising spatial transformation  
9 information.
- 10 13. A method comprising calculating a temporal interference pattern produced by an  
11 interference of a chosen input optical signal  $E_i(t)$  with an intended output optical  
12 signal  $E_o(t)$ , the chosen input signal and the intended output signal traveling within  
13 a common boundary in a common time frame, the calculated temporal interference  
14 pattern for forming a volume hologram in an optical medium.
- 15 14. The method of Claim 13, further comprising imparting the calculated temporal  
16 interference pattern into and/or onto an optical medium so as to form the volume  
17 hologram therein.
- 18 15. The method of Claim 13, further comprising:  
19 calculating a plurality of temporal interference patterns produced by respective  
20 interference of a plurality of chosen input optical signals  $E_i(t)$  with a respective  
21 plurality of intended output optical signals  $E_i(t)$ ; and  
22 calculating a total temporal interference pattern as a superposition of the plurality  
23 of temporal interference patterns, the total temporal interference pattern for  
24 forming a volume hologram in an optical medium.
- 25 16. The method of Claim 15, further comprising imparting the total temporal  
26 interference pattern into and/or onto an optical medium so as to form the volume  
27 hologram therein.
- 28 17. A method comprising:

1        imparting into the volume of a planar optical waveguide a pattern, thereby forming  
2        a volume hologram in the planar waveguide, the volume hologram comprising  
3        at least one of temporal, spectral, and spatial transformation information, the  
4        volume hologram comprising a plurality of diffractive elements exhibiting a  
5        positional variation in at least one of amplitude, optical separation, and spatial  
6        phase over some portion of the volume of the hologram, the information for  
7        transforming a chosen input signal into a chosen output signal as the input and  
8        output signals propagate within the planar waveguide.

9    18. The method of Claim 17, wherein the holographic pattern comprises temporal and  
10       spatial transformation information.

11   19. The method of Claim 17, wherein the holographic pattern comprises spectral and  
12       spatial transformation information.

13   20. The method of Claim 17, wherein the pattern is imparted using a technique chosen  
14       from the group consisting of photolithography, electron beam lithography,  
15       stamping, etching, mechanical abrasion, ultrasonic material removal, heat  
16       deformation, laser ablation, photosensitive exposure, and combinations thereof.

17   21. A method comprising:

18       imparting onto at least one slab face of a planar waveguide a pattern, thereby  
19       forming a volume hologram in the planar waveguide, the volume hologram  
20       comprising at least one of temporal, spectral, and spatial transformation  
21       information, the volume hologram comprising a plurality of diffractive elements  
22       exhibiting a positional variation in at least one of amplitude, optical separation,  
23       and spatial phase over some portion of the volume of the hologram, the  
24       information for transforming a chosen input signal into a chosen output signal  
25       as the input and output signals propagate within the planar waveguide.

26   22. The method of claim 21, wherein the volume hologram comprises temporal and  
27       spatial transformation information.

28   23. The method of claim 21, wherein the volume hologram comprises spectral and  
29       spatial transformation information.

- 1 24. The method of Claim 21, wherein the pattern is imparted using a technique chosen  
2 from the group consisting of photolithography, electron beam lithography,  
3 stamping, nanoimprinting, laser writing, etching, mechanical abrasion, ultrasonic  
4 material removal, heat deformation, laser ablation, photosensitive exposure, and  
5 combinations thereof.
- 6 25. The method of Claim 21, wherein the pattern is imparted on two faces of the  
7 substrate.
- 8 26. A product produced according to the method of Claim 21.
- 9 27. The method of Claim 21, further comprising depositing a layer on at least one slab  
10 face of the planar waveguide, and imparting the pattern onto and/or into the layer  
11 after deposition thereof on the planar waveguide, thereby imparting the pattern  
12 onto the planar waveguide and forming the volume hologram in the planar  
13 waveguide.
- 14 28. The method of Claim 27, wherein the pattern is imparted by spatially-selective  
15 deformation of the deposited layer.
- 16 29. The method of Claim 27, wherein the deposited layer comprises dielectric  
17 material.
- 18 30. The method of Claim 27, wherein the deposited layer comprises metallic material.
- 19 31. The method of Claim 27, wherein the deposited layer comprises photosensitive  
20 material, and the pattern is imparted by spatially-selective photo-exposure of the  
21 deposited layer.
- 22 32. A product produced according to the method of Claim 27.
- 23 33. A method comprising:  
24 imparting a pattern into and/or onto a material layer; and  
25 depositing the patterned material layer onto at least one slab face of a planar  
26 waveguide substrate after patterning the layer, thereby forming a volume  
27 hologram in the waveguide substrate, the volume hologram comprising at  
28 least one of temporal, spectral, and spatial transformation information, the

1 information for transforming a chosen input signal into a chosen output signal  
2 as the input and output signals propagate within the planar waveguide.

3 34. The method of Claim 33, wherein the transformation information comprises  
4 temporal and spatial transformation information.

5 35. The method of Claim 33, wherein the transformation information comprises  
6 spectral and spatial transformation information.

7 36. The method of Claim 33, wherein the patterned material layer comprises metallic  
8 material.

9 37. The method of Claim 33, wherein the patterned layer comprises dielectric material.

10 38. A product produced according to the method of Claim 33.

11 39. A method comprising:

12 imparting a pattern onto at least one surface of a support slab; and

13 pressing the support slab securely against a planar waveguide substrate so that

14 the patterned support slab forms a volume hologram in the waveguide

15 substrate, the volume hologram comprising at least one of temporal, spectral,

16 and spatial transformation information, the information for transforming a

17 chosen input signal into a chosen output signal as the input and output signals

18 propagate within the planar waveguide.

19 40. The method of Claim 39, wherein the holographic pattern comprises temporal and  
20 spatial transformation information.

21 41. The method of Claim 39, wherein the holographic pattern comprises spectral and  
22 spatial transformation information.

23 42. The method of Claim 39, further comprising bonding the support slab to the planar  
24 waveguide substrate.

25 43. A product produced according to the method of Claim 39.

26 44. A method comprising:

27 imprinting onto at least one slab face of a planar waveguide a pattern, thereby

28 forming a volume hologram in the planar waveguide, the volume hologram

1 comprising at least one of temporal, spectral, and spatial transformation  
2 information, the information for transforming a chosen input signal into a  
3 chosen output signal as the input and output signals propagate within the  
4 planar waveguide.

5 45. The method of claim 44, wherein the volume hologram comprises temporal and  
6 spatial transformation information.

7 46. The method of claim 44, wherein the volume hologram comprises spectral and  
8 spatial transformation information.

9 47. The method of Claim 44, wherein the pattern is imprinted by stamping, embossing,  
10 nanoimprinting, or laser writing, or combinations thereof.

11 48. The method of Claim 44, wherein the pattern is imprinted on two faces of the  
12 substrate.

13 49. A product produced according to the method of Claim 44.

14 50. The method of Claim 44, further comprising depositing a layer on at least one slab  
15 face of the planar waveguide, and imprinting the pattern onto the layer after  
16 deposition thereof on the planar waveguide, thereby imparting the pattern onto the  
17 planar waveguide and forming the volume hologram in the planar waveguide.

18 51. A product produced according to the method of Claim 50.

19 52. A method comprising:

20 spatially selectively exposing a photosensitive optical medium whose exposure

21 changes a physical characteristic of the medium, thereby forming a volume

22 hologram in the medium, the volume hologram comprising at least one of

23 temporal, spectral, and spatial transformation information, the volume

24 hologram comprising a plurality of diffractive elements exhibiting a positional

25 variation in at least one of amplitude, optical separation, and spatial phase

26 over some portion of the volume of the hologram, the information for

27 transforming a chosen input signal into a chosen output signal as the input and

28 output signals propagate within the optical medium.

- 1 53. The method of Claim 52, wherein the volume hologram comprises temporal and  
2 spatial transformation information.
- 3 54. The method of Claim 52, wherein the volume hologram comprises spectral and  
4 spatial transformation information.
- 5 55. The method of Claim 52, propagation of the input and output optical signals within  
6 the optical medium substantially unguided in three dimensions.
- 7 56. The method of Claim 52, wherein the optical medium comprises a planar optical  
8 waveguide, propagation of the input and output optical signals within the planar  
9 waveguide substantially guided in at least one dimension by the planar waveguide.
- 10 57. The method of Claim 52, wherein the physical characteristic that is changed is at  
11 least one of absorptivity, index of refraction, and reflectivity.
- 12 58. A product produced according to the method of Claim 52.